Left Ventricular Remodeling is Less While Left Atrial Remodeling is Greater in Inferior Compared to Anterior Myocardial Infarction: Importance of Ischemic Mitral Regurgitation*

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Abstract

Background. Left ventricular (LV) remodeling is greater in patients with anterior myocardial infarction (MI) compared to those with inferior MI. Left atrial (LA) remodeling is expected to have influences from both LV remodeling and mitral valve dysfunction or mitral regurgitation (MR), which is more frequent in inferior MI. Therefore, LA remodeling may not necessarily be less in inferior MI compared to anterior MI. The purpose of the study is comparison of LV and LA remodeling in patients with anteroseptal and inferior MI with or without MR.

Methods. In 61 consecutive patients with prior anterior MI, 33 with prior inferior MI, and 22 normal control subjects, LV and LA volumes were measured using biplane Simpson’s method, and MR fraction was quantified by Doppler echocardiography.

Results. Although patients with inferior MI had significantly less LV dilatation (LV end-diastolic volume: 91±11 vs. 125±45 vs. 106±19 ml, control vs. anterior vs. inferior, p<0.01) and reduction in LV ejection fraction (63±6 vs. 44±7 vs. 49±8 %, p<0.01), their LA dilatation was significantly greater compared to those with anterior MI (51±12 vs. 64±28 vs. 78±31 ml, p<0.01). Incidence of ischemic MR (fraction>20%) was significantly higher in patients with inferior MI compared to anterior MI (7/61 vs. 12/33, p<0.01). In selected patients without significant ischemic MR, LA dilatation was comparable between inferior and anterior MI (60±28 vs. 61±16 ml, n.s.).

Conclusions. Compared to patients with anterior MI, LV remodeling is significantly less but LA remodeling is significantly greater in inferior MI, suggesting the important role of ischemic MR to induce LA remodeling.

Key words: echocardiography, left atrial remodeling, mitral regurgitation

It is known that inferior myocardial infarction (MI) causes less left ventricular (LV) remodeling compared to anterior MI [1, 2]. However, mitral valve dysfunction or regurgitation (MR) is known to be greater in patients with inferior MI compared to those with ante-

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with prior inferior MI, and 22 normal controls were retrospectively enrolled in the study. Inclusion criteria were presence of prior anteroseptal or inferior MI diagnosed by 1) history of acute MI occurring more than 1 month previously, with serum creatine kinase level > twice the upper normal value, and 2) segmental LV wall motion abnormality of the anteroseptal or inferior wall. Exclusion criteria were recent MI (< 1 month), multiple MI’s, previous heart surgery, MR due to intrinsic mitral valve lesions (including rheumatic changes, infective vegetations, chordal or papillary muscle rupture), and other associated cardiac diseases such as aortic valve or congenital heart disease. Normal controls had normal echocardiograms and no known cardiovascular disease. Patient profiles are summarized in Table 1. All patients gave their informed consent, and the institutional committee on human research of Kagoshima University Hospital also approved the study protocol.

Two-dimensional and Doppler echocardiography. A standard two-dimensional and Doppler echocardiographic examination was performed with commercially available equipments (Toshiba SSH 380A, Tokyo, Japan; HDI-5000, ATL Ultrasound, Bothell, WA, USA; Philips Medical Systems, Sonos 5500, Andover, MA, USA; Sequoia, Siemens, Mountain View, CA, USA) in all patients.

Echocardiographic measurements were performed on an off-line video image analysis station. LV end-diastolic and end-systolic volumes were measured using the apical biplane Simpson’s method [7]. Left atrial volume was also measured in the end-systole using the Simpson’s method. MR volume was calculated as the difference between mitral filling volume and aortic forward stroke volume obtained by the product of mitral or aortic annular area and the flow velocity time integral at the level using pulsed Doppler echocardiography [8, 9]. MR fraction was then calculated as MR volume divided by mitral filling volume, and MR fraction > 20% was considered as significant [10].

Statistical analysis. Continuous numerous variables are expressed as mean value ± SD. Differences in variables between the 2 groups were assessed by the unpaired Student’s t-test. The relationships between continuous variables were evaluated by simple linear regression analysis. Categorical variables were compared with \( \chi^2 \) test. A p value < 0.05 was considered statistically significant.

Results

Echocardiographic findings and LA remodeling in anterior and inferior MI (entire patients) (Table 2)

Both patients with anterior and inferior MI had significantly larger LV end-diastolic and end-systolic volumes and lower ejection fraction compared to normal subjects (p<0.01). The increase in LV end-diastolic volume, end-systolic volume, and reduction in ejection fraction were significantly less in patients with inferior MI compared with anterior MI (p<0.01). However, MR fraction and the incidence of significant MR were significantly greater in patients with inferior MI (p<0.01). Both patients with anterior and inferior MI had significantly larger LA volume compared to normal subjects. In contrast to indices of LV remodeling, the increase in LA volume was significantly greater in patients with inferior MI compared with anterior MI (p<0.01).

Table 1. Patient profiles (entire patients)

<table>
<thead>
<tr>
<th></th>
<th>Control n=22</th>
<th>Anterior MI n=61 vs. Inferior MI n=33</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>65±12</td>
<td>66±11</td>
<td>N.S.</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>18/4</td>
<td>55/6</td>
<td>N.S.</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163±6</td>
<td>164±7</td>
<td>N.S.</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>58±7</td>
<td>59±8</td>
<td>N.S.</td>
</tr>
<tr>
<td>Time lapse after acute MI (years)</td>
<td>0±0</td>
<td>2.3±2.7</td>
<td>2.5±2.9</td>
</tr>
<tr>
<td>Associated Af</td>
<td>0/22</td>
<td>3/61</td>
<td>1/33</td>
</tr>
</tbody>
</table>

MI: myocardial infarction, M: male, F: female, Af: atrial fibrillation, P value for comparison between anterior and inferior MI.
In order to evaluate LA remodeling in the absence of ischemic MR, patients without significant MR were selected for further analysis. Patients with anterior MI but without significant MR still had significantly larger LV end-diastolic volume compared to those with inferior MI or normal subjects (p<0.01). However, LV end-diastolic volume in patients with inferior MI but without significant MR was not significantly different to that in normal subjects. Increase in LV end-systolic volume and reduction in LV ejection fraction were still significant in both patients with anterior and inferior MI compared to normal controls (p<0.01). However, LV end-diastolic volume, end-systolic volume, and reduction in ejection fraction were again significantly less in patients with inferior MI compared with anterior MI (p<0.01). MR fraction was not significantly different between patients with anterior and inferior MI by selection of patients. Both patients with anterior and inferior MI still had significantly larger LA volume compared to normal subjects (p<0.05). In contrast to the larger LA volume in all the patients with inferior MI compared to those with anterior MI, the increase in LA volume was not significantly different between selected patients with inferior and anterior MI without significant ischemic MR.

Determinants of LA remodeling

Simple linear regression analysis identified significant correlation between LA volume and MR fraction (r=0.40, p<0.01). LA volume was not significantly related to LV end-diastolic volume, end-systolic volume, or ejection fraction due to multiple patients with discrepant LA volume and indices of LV dysfunction. Figure 1 shows 2 representative patients with anterior MI.
and inferior MI. The patient with inferior MI has less LV remodeling, however, this patient has greater MR and LA remodeling.

**Discussion**
The results of the present study has demonstrated that LA remodeling is greater in patients with inferior MI compared to those with anterior MI, while LV remodeling is less in patients with inferior MI. This disproportionately predominant LA remodeling was not observed in patients with inferior MI but without associated ischemic MR. In addition, ischemic MR was the only independent determinant of LA remodeling by regression analysis. Therefore, ischemic MR plays an important role in the development of LA remodeling. Of note is that the degree of ischemic MR was only mild to moderate, therefore, the study also demonstrates the importance of only mild to moderate degree of ischemic MR.

**Relation to previous studies**
Previous studies have demonstrated that ischemic MR is a vexing problem in patients with ischemic heart disease and the basic mechanism of the MR is leaflet tethering due to the deformity of mitral valve complex or outward displacement of papillary muscles [2, 8, 11-21]. Higher incidence of ischemic MR in patients with inferior MI has been demonstrated and explained as greater deformity of mitral valve complex in inferior compared to anterior MI [1, 2]. The current study confirmed these previous investigations. Ischemic MR has also been demonstrated as an independent risk of patients with ischemic heart disease [21, 22-25]. These studies further emphasized that mild degree of ischemic MR is also a significant risk for these patients. On the other hand, LA remodeling has been demonstrated as an important risk for patients with cardiovascular disease [26-28]. This study further demonstrated the important role of ischemic MR in the LA remodeling with disproportionately predominant LA remodeling in inferior MI, confirming the previous reports.

**Clinical implications**
The importance of LV remodeling in patients with ischemic heart disease is well recognized. It is related to the development of ischemic MR [20, 21], congestive heart failure [29], and patients prognosis [30, 31]. Recently, the importance of LA remodeling is also emphasized [26-28]. LA remodeling can be related to LV remodeling, therefore, it is expected that the degree of LA remodeling is proportional to the degree of LV remodeling. However, there was no significant correlation between the indices of LV remodeling and LA volume. Potential measurement error of LV volume with suboptimal images may be related to this lack of significant relations. However, lack of significant relation between LV end-diastolic volume, end-

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**Fig. 1.** Representative 2 patients with anterior and inferior myocardial infarction. The patient with inferior infarction has less left ventricular remodeling, however, has greater mitral regurgitation and left atrial remodeling.
systolic volume, or ejection fraction and patients’ outcome has been reported [32]. Therefore, LA remodeling, with close correlation to prognosis, can be only loosely related to LV volume or ejection fraction, which may resulted in the lack of significant relation between LV and LA volumes in the present study.

This study has demonstrated the importance of ischemic MR in the development of LA remodeling. This study further demonstrated disproportionately predominant LA remodeling in patients with inferior MI, due to the associated mild to moderate ischemic MR, compared to those with anterior MI. Therefore, this study emphasized the importance of ischemic MR, even with mild or moderate degree, in the development of LA remodeling. In patients with MR due to organic leaflet lesion, such as flail mitral valve, only severe MR significantly affects patients’ prognoses [33]. This study suggests that moderate or only mild degree of MR can also be important, if its etiology is ischemic.

**Limitations**

This study was performed in consecutive patients with prior inferior or anterior MI who underwent echocardiographic examination due to clinical reasons. The study subjects were not consecutive patients who developed inferior or anterior acute MI. Therefore, the selection of patients is not totally unbiased. Lack of significant correlations between LA volume and indices of LV remodeling may be related to the patient selection. LA remodeling can be dynamic. It may vary according to the phase of MI. No patient with acute MI was included in the study. In addition, clinical significance of the disproportionately predominant LA remodeling was not clarified from this study. It is not clear whether prognosis of patients with inferior MI with less LV remodeling but greater LA remodeling is equal, worse, or better compared to those with anterior MI with greater LV remodeling but with less LA remodeling. Further studies with a large number of patients, including those with acute MI, are necessary to address these issues. Nevertheless, the purpose of the present study was achieved by demonstrating the importance of ischemic MR in the development of LA remodeling and disproportionately predominant LA remodeling in patients with inferior MI compared to those with anterior MI.

**Conclusions**

Compared to patients with anterior MI, LV remodeling is significantly less but LA remodeling is significantly greater in inferior MI, suggesting the important role of ischemic MR to induce LA remodeling.

**References**


